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The formulæ for calculation of an ephemeris are as follows:

(1) $u - 13{\cdot}89 \sin u = +1^\circ{\cdot}057\,(t - 1778{\cdot}81)$,

(2) $\tan \tfrac{1}{2}V = 1{\cdot}28 \tan \tfrac{1}{2}u$,

(3) $\tan(\theta_c - 89^\circ\ 45') = 0{\cdot}6965 \tan(V + 203^\circ\ 14')$.

(4) $\rho = 2''{\cdot}25\,(1 - 0{\cdot}2425 \cos u)\,\dfrac{\cos(V + 203^\circ\ 14')}{\cos(\theta_c - 89^\circ\ 45')}$;

where u is the eccentric anomaly, and V the true anomaly for the epoch t, θ_c the required position angle, and ρ the distance.

The position of the star is for 1886·0

R.A. $13^h\ 28^m\ 29^s$
$+0^\circ\ 16'\ 6''$.

It is Lalande 25087, and lies closely *np ζ Virginis*. It was estimated 7^m by Lalande, and 7·0 at Cordoba. According to Struve the magnitudes of the components are 7·8 and 8·9.

The orbit has been previously computed by Casey, who finds a period of 401·0 years, with T = 1797·42, and $e = 0{\cdot}5079$.

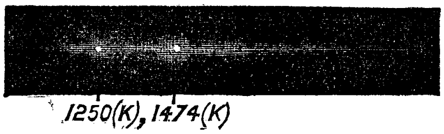
Ballysodare, Co. Sligo:
1886, *Oct.* 14.

Reply to certain Questions raised before the Royal Astronomical Society at the Meeting on 1886, *March* 12, *concerning the matter detailed in a Paper entitled* "*Bright Lines in Stellar Spectra.*"

By O. T. Sherman.

(*Communicated by the Secretaries.*)

The object of the method employed is to render the image of the bright line light as broad and intense as may be, and the intensity of the background light a minimum. A successful application is presented in the spectrum of *Nova Andromedæ*, which is shown in an adjoining cut.* Along a faint bluish line there were seen bright stellar images surrounded by a haze. These were termed bright lines.



Portion of the Spectrum of Nova Andromedæ.

In practice the background light is often sufficiently intense

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* The haze surrounding the stellar image is somewhat exaggerated in the drawing.

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to cut down the haze surrounding the point, so that the image appears as a bright knot, fuzzy or sharply bounded, beading or embedded in the bright linear spectrum. Such is the case with β *Lyræ* or γ *Cassiopeiæ,* as seen with the means at command.

One has to distinguish between bright line, bright background space, and mere disturbance in the light of the spectrum. The principle upon which the discrimination is made is that the bright background space being the effect of contrast remains constant in both place and intensity. The disturbance in the light of the star is constant in neither intensity nor position. The bright line is constant in place but not in intensity. For each star, therefore, an extended series of observations is necessary.

The first remarks made concern (*a*) the adjustment of the instrument; (*b*) the action of the lines; (*c*) the position of the cylindrical lens.

(*a*) "First, 'previous to each night's work, the instrument was adjusted upon the Sun; a solar spot when possible being brought sharply in focus on the jaws of the slit.' This would seem a proper and necessary adjustment, and would suffice for the centre of the spectrum; but for the extreme rays, especially the blue and violet, the spectroscope would not be in the proper focus of the equatorial. There is a paragraph in Mr. Sherman's Paper which at least suggests that the extreme ends of the spectrum suffered in this way. . . ." The adjustments of the spectroscope were such as to give good definition for the solar spectrum. It was presumed they would also for the stellar. The adjustments have been regarded. Also two-thirds of the lines announced for γ *Cassiopeiæ* lie between D_3 and H $\gamma^{(1)}$,* a space not encroaching very far on the extreme ends of the spectrum. It is thought the remark will hold generally true.

(*b*) "There is a paragraph in Mr. Sherman's Paper which at least suggests that the extreme ends of the spectrum suffered in this way: 'At the red end, under a sharp focus, they' (the bright lines) 'stand out the full breadth of the spectrum, bearing somewhat the same relation to the background as the prominences to the solar spectrum. In the brighter portion of the spectrum they are cut down to bright star points. At the blue end they become more distinct, but not so sharp as at the red. At times they shine with almost a metallic brilliancy; at other times they are faint, faded, and easily passed over. Certain sets appear to be prominent at times; others at other times.' It seems very difficult to believe that this can be a description of true stellar bright lines, while it is quite conceivable that lines due to some instrumental effect might present just such an appearance in a spectroscope, adjusted as Mr. Sherman's seems to have been, only for the centre of the spectrum. . . ."

There are at least two other observers who agree as to the

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* American Journal of Science, Dec. 1885.

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action of the bright line. A note taken from the *Astronomische Nachrichten*, Nos. 2651–2652, is copied from the *Observatory* of April, 1885.

"*Variations in the Spectrum of β Lyræ.*—In the summer and autumn of 1883, Dr. N. de Konkoly and Herr E. von Gothard detected a certain amount of variability in the C, D_3 and F lines in the spectra of γ *Cassiopeiæ* and β *Lyræ*, in which they are frequently seen to shine as bright lines. During 1884, Herr von Gothard has followed up his investigations and observed the spectrum of β *Lyræ* on thirty nights. On nine of these occasions the D_3 line was seen to be more or less bright. On July 13 it was even described as 'almost dazzling'; on several other nights its presence was only suspected; on ten nights no trace of it was seen, so that it presented on different occasions every possible degree of change of brightness from great brilliancy down to total disappearance. The C line was also seen to be reversed on many occasions, and was frequently very brilliant, but on others it was only faint, was difficult to see, or was evidently a dark line. The F line was not so often noticed to appear bright; its reversal would naturally be less easily observed than that of C or D_3. Herr von Gothard was not able to satisfactorily determine the length of the period of variability; it was evidently very short, and a period of about seven days seemed to suit the observations fairly well. It should be added that the three lines appear to vary in perfect accord with each other . . . ."

Again, "both show bright lines of hydrogen and helium, so that the peculiarity of their condition probably consists in the unusual extent and intense ignition of their chromospheric surroundings. But this condition is subject to fluctuations. The brilliant rays indicative of it died out during nine years, 1874–1883. . . ."[*]

Again, the bright lines of the solar chromosphere show a similar variation in both visibility and frequency, as is shown in the frequency and maximum brilliancy numbers in Young's "Catalogue of Bright Lines in the Spectrum of the Solar Atmosphere."[†]

Again, one might appeal to our knowledge derived from "new" or "temporary" stars—for example, the changes in the spectrum of T *Coronæ*.[‡]

Again, a similar action is not entirely unknown even in laboratory work. For the sake of an example we quote,[§] "When the carbonic acid is displaced by hydrogen, the hydrogen lines appear, the hydro-carbon flame and the triple sets remaining bright, but in this gas the flame group at 4310 is particularly well marked, and *the carbon line at* 4266 *keeps flashing in occa-*

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[*] History of Astronomy during the Nineteenth Century, Clerke, p. 420.

[†] American Journal of Science, Nov. 1872.

[‡] History of Astronomy during the Nineteenth Century, Clerke, p. 422.

[§] On the Origin of the Hydro-Carbon Flame Spectrum, Profs. G. D. Liveing and J. Dewar, Proc. Roy. Soc. Vol. 34, 1882–1883, p. 429.

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sionally." Or, in general, examples might be drawn from the whole range of phenomena showing change in spectra depending upon temperature or upon mechanical mixture with some other gas.[*]

(*c*) "Particularly as he placed his cylindrical lens not before the slit, nor even in the viewing telescope, but between the eyepiece and his eye."

The cylindrical lens need have and properly has no place in the arrangement. Used at the commencement of the work, it has long since been abandoned. As bearing on the point, however, the following quotation which has come to my knowledge within a day or two is not without interest. It comes from one who, having searched in the same field without being satisfied, makes suggestions for those that follow, "and to ask others with greater optical power to search for the lines, *taking the precaution to use the cylindrical lens close to the eye*, and not to apply it to the instrument until the rays to be examined are absolutely in focus on the slit, *if a slit is used.* It is possible scintillation may help matters."[†]

Under the second head is treated (*a*) the width of the slit; (*b*) the accuracy of the measures; (*c*) the generality of the appearances; (*d*) the fact that they have not been observed before.

Second (*a*). "Mr. Sherman used an unusually wide slit, '$5^{\text{mm.}}$ or more.' I think most stellar spectroscopists will pronounce this to have been fully 100 times too wide. $5^{\text{mm.}}$ in the focus of the 8-inch object-glass would correspond to 6′ of arc. It seems hard to see what purpose a slit of so great a width would serve, and in what essential feature it differed from no slit at all."

It practically is no slit at all. A glance at the quotation just above is not without interest. However wide the metallic jaws may be, the practical slit is the stellar diffraction shield for an eight-inch glass, about three seconds of arc in diameter.[‡]

(*b*) "And it is also difficult to place much confidence in measures made with so wide a slit, especially as the collimator only measures 6 inches in focal length, so that no stress can be laid upon the correspondence between the bright lines observed and those seen in the solar chromosphere."

Since the practical slit is three seconds in place of six minutes, it is hoped that this objection falls. The light of the shield fades off rapidly towards the edge, leaving a sharp central point to be set upon, or a fuzzy disc to be bisected. The measures seem therefore, in point of accuracy, comparable with

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[*] See the work of Profs. Liveing and Dewar, Proc. Roy. Soc. Vols. 27 and 36.

[†] Note on Bright Lines in the Spectra of Stars and Nebulæ. By J. Norman Lockyer. Proc. Roy. Soc. Vol. 27, p. 51.

[‡] Hermann Struve, Mém. de l'Acad. Impériale des Sciences de St. Pétersbourg, VII$^{\text{e}}$ Série, Tome XXX. No. 8. Airy, Transactions of the Cambridge Philosophical Society, Vol. V. part iii.

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those obtainable with a slit somewhat less in width than the stellar diffraction image, and some stress seems due to their approximate agreement with the solar atmospheric lines. A greater conditioning circumstance seems to be the use of a thick wire.

(*c*) "The most suspicious circumstance of all, however, is, I think, that so far Mr. Sherman has never failed to see bright lines in any star which he has examined. . . . . I have had occasion to notice on more than one occasion that a stellar spectrum which is full of dark lines or bands may, when badly seen, give a very perfect illusion of bright lines; the dark lines escaping recognition as such, but producing their effect by making the parts of the spectrum most free from them shine out by contrast like a veritable chromospheric spectrum."

The method by which it was hoped to distinguish between bright background space is already explained. It was hasty to claim bright lines for numerous stars. The announcement should have awaited the completion of the series of observations. Credence for the statement without such a series cannot be asked, but it is asked that the result of the series be awaited.

(*d*) "And that though 'sometimes they shine with almost metallic brilliancy,' yet no previous observer has detected them."

The spectroscopic arrangement is considerably different from that usually employed. Although no assertion of the existence of the lines has reached me, there is at least one who has suspected them, as the following quotation shows:* "Two years ago (1876) I searched for indications of a large chromosphere in the case of *a Lyræ* and some other stars. I believe I had glimpses of bright lines at F and *b*, but if this discussion [between Huggins and Stone] had not arisen I should have still hesitated to mention this, as I had been hoping for an increase of optical power."

In closing one may perhaps draw attention to this fact, that the result is not at variance with our best knowledge of stellar constitution. Speaking of the lesson to be learned from T *Coronæ*, a recent writer says: "No clear dividing line can be drawn between stars and nebulæ, but that in what are called planetary nebulæ on the one side and in 'gaseous stars' (those giving a spectrum of bright lines) on the other, we meet with transitional forms serving to bridge the gap"† between the faintly lucent nebula and the highly-finished star, and among the stars themselves one may readily pursue every value of the ratio expressing the relation between the light from the stellar nucleus and from the stellar atmosphere. While the arrangement which will bring out the absorption lines will hide all but the brightest of the gaseous lines, the method just described is, I think, bringing out those lines which belong to the gaseous envelope.

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* Note on Bright Lines in the Spectra of Stars and Nebulæ. By J. Norman Lockyer. Proc. Roy. Soc. Vol. 27, p. 50.

† History of Astronomy during the Nineteenth Century, Clerke, pp. 422–423.

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Bands observed in the Spectra of Sun-spots at Stonyhurst Observatory. By the Rev. A. Cortie, S.J.

(*Communicated by the Rev. S. J. Perry.*)

There are three kinds of bands which have been observed in the spectra of Sun-spots. The first, which is a certain fuzzy appearance surrounding the widened portions of the dark lines, has been very frequently seen, and is only a particular phase of the widening of the line. The second is an intensifying of the general absorption due to a Sun-spot in particular parts of the spectrum. The third is the appearance of real bands in the selective absorption due to a spot. The present paper contains some observations of each of these kinds of bands.

With regard to the hazy appearance or fuzziness surrounding a widened line, it is usually and most easily observed on the D lines, although not peculiar to them. In a spot in the S. F. quadrant of the Sun observed on November 15, 1883, the widening of all the lines, instead of a dark and distinct thickening of the same, presented the appearance of a penumbral shade at either side of the dark central line. But this haziness has been most markedly attached to the D lines on several occasions. Thus on September 29, 1884, and on January 14, 1886, these two lines were not only widened and fuzzy, but were also reversed in one portion of their length. Sometimes the haze exists surrounding the lines, while the lines themselves are not widened, as on October 2 and 3 of the present year in a small spot. In the part of the spectrum between D and C, Ångström gives a line as due to *Na* at 6160·23 a little more refrangible than a strong *Ca* line at 6160·40. This *Na* line is drawn as double in the maps of Fievez and Piazzi Smyth, and with good definition, and using a dispersion of twelve prisms, it has been usually so seen. This double is always remarkably widened in the spectra of spots, and, moreover, the widening is of the nature of the fuzzy band seen at times in connection with the D lines. If a moderate dispersion of six prisms be used, it appears as if the *Ca* line adjoining this faint double was considerably widened and displaced towards the violet. But on using a great dispersion the widening is seen to be principally due to these faint *Na* lines, although the thick *Ca* line is usually also affected. On June 25, 1885, and on January 14, 1886, the widened *Ca* line was seen running through the haze due to these *Na* lines. In the small spot of October 2 of the present year, the band due to these lines was at least one-tenth mètre in breadth. Finally it may be mentioned in connection with the D lines, that when the widening on the two sides is unequal, the balance is almost invariably in favour of the violet or more refrangible side of the lines.